Indoor Particle Sources and Spatial Variation of Particle Concentration in a Prison

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Due to the very specific nature of prisons, there have been very few limited indoor air quality studies. Thus, unlike other indoor environments, the understanding of indoor air quality in prisons is poor.

The aim of project was to investigate the indoor particle sources and spatial variation of particle concentration in a maximum security prison in a rural area in Australia.

- Measurement: Indoor/outdoor total particle number (PN) concentration by TSI CPC, $PM_{2.5}$ concentration by TSI DustTrak, PN concentration in various locations, including a workshop for inmates within the prison by a NanoTracer (NT).
- One week measurement were conducted twice immediately before (pre-ban), and six months after (post-ban) the introduction of the smoke free buildings policy in this prison

Results:

- There were very strong indoor particle sources in some of these units, which could increase indoor PN and $PM_{2.5}$ concentrations from about 5×10^3 (p cm^{-3}) to above 100×10^3 (p cm^{-3}), and from about 25 µg m^{-3} to 435 µg m^{-3}, respectively.
- Visible indoor smoking activities could be observed during the pre-ban but could not in the post-ban. However, data analysis of post-ban indicated that clandestine smoking among inmates after guards departed was occurring. An example of diurnal variations of indoor and outdoor PN and $PM_{2.5}$ concentrations of post-ban is shown in Figure 1. Figure 1 provides an example of this clandestine smoking.
- The main indoor particle sources identified in the prison were smoking, cooking, washing and cleaning.
- From the Table 1, spatial variations of average particle concentrations can be seen. The overall 24-h average $PM_{2.5}$ concentration in Unit A was more than double than those of Units B and C during the pre-ban. More significant spatial variations of average particle concentrations were observed during the post-ban. The overall 24-h average $PM_{2.5}$ concentration in Unit C was more than 10 time higher than that of Unit A. The main reason for the spatial variation was the different strength of indoor particle sources between these units.

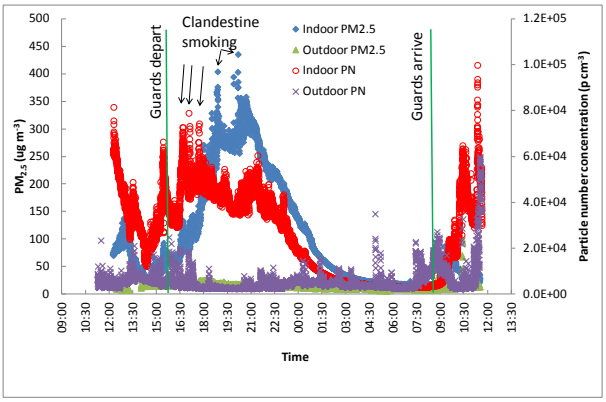

Figure 1. Time series of indoor PN and $PM_{2.5}$ concentrations in a unit.

Table 1. A summary of overall average 24 hour indoor $PM_{2.5}$ concentrations (µg m^{-3}) and PN concentrations ($\times 10^3$ p cm^{-3}) measured during the pre-ban and post-ban at the four locations, as well as I/O ratios.

			Average	I/O ratio
Unit A	$PM_{2.5}$	**1**	**17**	1.24
	$PM_{2.5}$	2	**7**	0.61
Unit B	$PM_{2.5}$	**1**	**8**	1.11
	$PM_{2.5}$	2	**13**	1.12
Unit C	$PM_{2.5}$	**1**	**6**	1.06
	$PM_{2.5}$	2	**71**	5.46
Unit D	$PM_{2.5}$	**1**	**NA**	N/A
	$PM_{2.5}$	2	**22**	1.72
Unit B	PN	**1**	**5.13**	1.02
	PN	2	**18.2**	2.45
Unit C	PN	**1**	**4.88**	1.57
	PN	2	**24.0**	4.18

1: pre-ban; 2: post-ban; N/A: no data available

- The PN concentrations within the workshop show significant spatial variations and were 4 to 50 times higher than outdoors. Average PN concentrations in the guard's station within the workshop (from 107×10^3 p cm^{-3} to 139×10^3 p cm^{-3}) were more than 10 times higher than those in other locations frequented by guards. In the designated outdoor smoking area, the PN concentration levels were higher than those in the workshop. The main indoor particle sources identified were cooking in the officer's station, and spray painting and vacuuming in the workshop area.

This study provided PN concentration variation and particle sources in prison at first time.